UNITED STATES SPECIAL OPERATIONS COMMAND
16.3 Small Business Innovation Research (SBIR) Program
Proposal Submission Instructions

Introduction

The United States Special Operations Command (USSOCOM) seeks small businesses with strong Research and Development (R&D) capabilities to pursue and commercialize technologies needed by the Special Operations Forces (SOF). The USSOCOM Program Executive Officers (PEOs) submitted topics to the USSOCOM SBIR Program Manager (PM) that may transition to an acquisition Program of Record or Concept of Operation. In turn, the USSOCOM SBIR PM submitted the topics to the Department of Defense (DoD) for incorporation into the DoD 16.3 SBIR Broad Agency Announcement (BAA).

A thorough reading of the DoD 16.3 SBIR BAA, prior to reading these USSOCOM instructions is mandatory. These USSOCOM instructions are supplemental to the DoD guidance; i.e., designed to tailor, enhance and explain certain unique aspects of the USSOCOM SBIR program.

Contact with USSOCOM

During the Pre-release Period of the DoD 16.3 SBIR BAA, any questions should be limited to specific information related to improving the understanding of a particular topic's requirements which must be submitted in writing by email to sbir@socom.mil. **All inquiries must include the topic number in the subject line of the e-mail.**

During the Open Period, follow the instructions described in section 4.15.d of the DoD 16.3 SBIR BAA instructions for additional information on the SBIR/STTR Interactive Topic Information System (SITIS).

During the Source Selection Period, e-mail is the only acceptable method of communication that will be used by the Government Contracting Officer (CO) to notify the Offeror if they have or have not been selected for award.

Note: Site visits will not be permitted during the Pre-release and Open Periods of the DoD 16.3 SBIR BAA.

Phase I and Phase II Proposal Submission

USSOCOM will only accept Phase I proposals for the topics included in these USSOCOM instructions. USSOCOM will only fund Phase I proposals most likely to succeed in meeting USSOCOM's needs.

Small business concerns awarded a Phase I contract may choose to submit a Phase II proposal no later than thirty (30) calendar days following the end of the Phase I contract. Submission of a Phase II proposal is not included as part of the Phase I contract.

Potential Offerors shall submit all Phase I and Phase II proposals along with a comprehensive Statement of Work (SOW) in accordance with the DoD 16.3 SBIR BAA via the following link https://sbir.defensebusiness.org (Section 5.0 Phase I Proposal and Section 7.0 Phase II Proposal) with one exception. For Phase II proposals only, Offerors must complete the cost volume using the Cost Proposal Form posted on the USSOCOM section of the submission site. Offerors can contact the SBIR Help Desk at SBIRHelp@ByteCubed.com or 1-800-348-0787 for assistance in obtaining the Cost Proposal Form. The Cost Proposal information (PDF format) shall be appended to and submitted with the Phase II Technical Volume. For Phase I and Phase II proposals, the Technical Volume shall not exceed 20 pages. Proposals with a Technical Volume exceeding 20 pages will not be evaluated. The appended Cost Proposal does not count toward the 20-page Technical Volume limit, nor does the Company Commercialization Report.

Note: A comprehensive SOW clearly explains and defines the Offeror's approach and solution on how it will meet or exceed USSOCOM's programmatic objectives. Progress will be measured and conveyed to USSOCOM via a set of deliverables described within each topic description.

Phase I Evaluation

USSOCOM conducts a formal source selection process to determine which proposals should be awarded Phase I SBIR contracts. USSOCOM evaluates Phase I proposals using the evaluation criteria specified in Section 6.0 titled "Phase I Evaluation Criteria" of the DoD 16.3 SBIR BAA.

USSOCOM considers each Phase I feasibility study as a separate and distinct study that does not compete against each other. The feasible solutions that result from the Phase I studies are considered technology options that can be applied when needed to solve SOF capability shortfalls. Phase I feasibility options, not immediately pursued after the conclusion of the Phase I, may move forward to the Phase II demonstration effort to satisfy future requirements.

Written Debriefing: A non-selected Offeror may submit a written request for a written debriefing only within 30 calendar days of receipt of notification of non-selection. USSOCOM will provide a written debriefing within 30 calendar days of an Offeror's written request. (These component-unique instructions are in accordance with paragraph 4.10, titled "Debriefing", of the DoD 16.3 SBIR BAA).

Phase I Awards

USSOCOM's SBIR Program is small compared to most other participating DoD Components and, on average, awards three Phase I contracts per topic. The maximum amount of SBIR funding for a Phase I award is $150,000 with a period of performance limited to six months. USSOCOM does not include options in the resulting Phase I SBIR contracts. Phase I SBIR contracts are Firm Fixed Price.

Phase I Kick-Off and Out-Brief Meetings: USSOCOM conducts Kick-Off and Out-Brief meetings during the Phase I period of performance. Firms selected for a Phase I SBIR contract shall have the ability to participate in the Kick-Off and Out-Brief meetings via electronic media mutually agreed upon by the firm and the Contracting Officer Representative (COR).

Phase II Evaluation

Each Offeror's Phase II proposal will be assessed as an independent technology pursuit. USSOCOM conducts a review process to determine which proposals should result in Phase II SBIR contracts. While not a formal source selection, USSOCOM reviews Phase II proposals using the criteria specified in Section 8.0 titled "Phase II Evaluation Criteria" of the DoD 16.3 SBIR BAA.

Written Debriefing: A non-selected Offeror may submit a written request for a written debriefing only within 30 calendar days of receipt of notification of non-selection. USSOCOM will provide a written debriefing within 30 calendar days of an Offeror's written request. (These component-unique instructions are in accordance with paragraph 4.10, titled "Debriefing", of the DoD 16.3 SBIR BAA).

Phase II Awards

The timing of selection for a Phase II award will be dependent upon USSOCOM's current requirements and available resources.

A Phase II award typically has a period of performance between 12 to 24 months with an award amount between $750,000 to $1,000,000. Proposals should be based on realistic cost and time estimates, and not on the maximum time and/or dollars budgeted. In preparing the proposal, Offerors should consider that USSOCOM's workload and operational tempo will preclude extensive access to Government and military personnel beyond established periodic reviews.

The Federal Acquisition Regulation mandate to maximize competition is satisfied during the Phase I source selection process. Only those Offerors awarded Phase I contracts are allowed to submit Phase II proposals.

USSOCOM SBIR Program Point of Contact: Inquiries concerning the USSOCOM SBIR Program should be addressed to sbir@socom.mil.

USSOCOM SBIR 16.3 Topic Index

USSOCOM SBIR 16.3 Topic Descriptions

SOCOM163-001 TITLE: Acoustic Signature Reduction

TECHNOLOGY AREA(S): Air Platform, Electronics, Materials/Processes

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 5.4.c.(8) of the solicitation.

OBJECTIVE: The objective of this effort is to reduce acoustic signatures of existing Special Operations Forces (SOF) fixed wing aircraft (manned and unmanned) using innovative technology solutions.

DESCRIPTION: Current SOF aircraft possess characteristic acoustic signatures that help adversaries identify and locate these aircraft. Reducing and/or masking acoustic signatures can significantly and directly contribute to the operators successfully accomplishing their missions.

PHASE I: The purpose of this technology pursuit is to determine what is in the art of the possible to reduce or eliminate acoustic signatures on aviation platforms. Offerors should consider all options/techniques to mask, filter, attenuate, and/or muffle acoustic signatures to reduce aviation acoustic signatures as well as consider the use of new material combinations, emerging technologies and all other possible solutions. The innovative technologies and techniques pursued in this Phase should not be directed to a specific SOF platform. During Phase I the offeror will discover potential innovative technology solutions/techniques and conduct a thorough analysis to identify the most promising solutions that would result in significant acoustic signature reductions when compared with other viable solutions. Acoustic signature reduction can be but is not limited to following areas:

- engine noise
- propeller noise
- air flow noise

Solutions that require building or acquiring a new aircraft is not a viable solution and will not be considered.

The objective of this USSOCOM Phase I SBIR effort is to conduct and document the results of a thorough feasibility study to investigate what is in the art of the possible within the given trade space that will satisfy a needed technology. The feasibility study should investigate all known options that meet or exceed the minimum performance parameters specified in this write up. It should also address the risks and potential payoffs of the innovative technology options that are investigated and recommend the option that best achieves the objective of this technology pursuit. The funds obligated on the resulting Phase I SBIR contracts are to be used for the sole purpose of conducting a thorough feasibility study using scientific experiments and laboratory studies as necessary. Operational prototypes will not be developed with USSOCOM SBIR funds during Phase I feasibility studies. Operational prototypes developed with other than SBIR funds that are provided at the end of Phase I feasibility studies will not be considered in deciding what firm(s) will be selected for Phase II.

PHASE II: Develop a prototype to demonstrate the technology that was determined to be the most feasible acoustic noise reduction solution during Phase I. The demonstration will be modeled by using a SOF representative platform’s acoustic signature (offeror can select the specific platform they desire to use for Phase II as long as it was similar to and representative of an existing SOF platform) to demonstrate that reduced acoustic signatures can be achieved using innovative technologies or techniques. The offeror will define/demonstrate the signature reductions either by actual measurement or by analysis and/or modeling and simulation using an existing SOF platform’s acoustic signature (measured by the offeror) compared to the signature after using the selected solution (also measured by the offeror). Ambient noise will be the same for measurements both before and after the solution is implemented. The Phase II effort will also require the offeror to provide:

- A Rough Order of Magnitude cost estimate for implementing the solution on the SOF platform selected.
- An estimate of any impact the solution will have on endurance, payload, and reliability.

PHASE III DUAL USE APPLICATIONS: Applicable to all Services, police, and commercial aviation and Special Weapons and tactics (SWAT) aviation platforms.

REFERENCES:
1. “Lockheed YO-3 Quiet Star”: https://en.wikipedia.org/wiki/Lockheed_YO-3

KEYWORDS: Acoustic Suppression

NOTE: During the Pre-Release stage of the 2016.3 DoD SBIR Solicitation, all technical questions related to this topic shall be addressed to sbir@socom.mil.

SOCOM163-002 TITLE: Advanced Durability Systems for Unmanned Aerial Vehicle Propulsion

TECHNOLOGY AREA(S): Air Platform

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 5.4.c.(8) of the solicitation.

OBJECTIVE: The objective of this technology pursuit is to improve Unmanned Aerial Vehicle (UAV) engine propulsion performance and durability using advanced designs/materials for bearing, housing, and rotating components/systems.

DESCRIPTION: UAV engines currently suffer from durability issues resulting in frequent overhauls. Incorporating advanced durability systems could lead to longer durations between engine overhaul times and increased engine life resulting in a larger payback per UAV investment. These advanced durability systems can be applied to bearings, rotating components and static components to increase the life and times between overhauls.

Bearings are an essential part of all UAV engine propulsion system. As technologies continue to advance in current air vehicles, more demands are being made on bearing capability. With an increase in the demand of bearing capacity, comes an increased risk of bearing fatigue and wear caused by heavier loading, inadequate/unsuitable lubrication and overheating. Future engine improvements need to incorporate advanced bearing designs and concepts to increase bearing durability and thus increase overhaul time of UAV engines. Advanced durability concepts should include but are not limited to ceramic ball bearings and fuel lubricated bearings. Ceramic ball bearings have advantages of higher operating speeds, increased stiffness, lower friction, and less heat generation. Using ceramic bearings in UAV engines can reduce wear on the bearings through an increase in engine durability. Further, fuel (JP-8) lubricated bearings offer substantial benefits resulting from the elimination of the conventional recirculating lubrication system.

Metal matrix composites (MMC) offer added strength and durability that can be incorporated in both engine housings and rotating components where ceramic matrix composites (CMC) also offer benefits with respect to heat transfer in the engine and housing and reduced engine weight. The benefits offered by composite and ceramic materials are high strength to weight ratios, high temperature tolerance, low coefficients of thermal expansion, low coefficients of friction, and favorable lubrication properties. The high strength to weight ratio is a favorable property for engine components as it reduces the rotational mass of the engine and increases the specific power. The low coefficients of expansion of these materials will allow tighter tolerances between moving and static components of the engines which could lead to increased durability and longer engine life. Applications for this technology include engine liners, coatings for combustion surfaces, bearing cages and housings, rotating shafts, pistons, and rotors.

PHASE I: Conduct a feasibility study of advanced durability systems that can be incorporated into bearings, rotating components, and static components of engines to increase durability of current UAV engine propulsion systems. The study should include but is not limited to ceramics, metal matrix composites, ceramic matrix composites, fuel (JP-8) lubricated bearings, carbon-carbon bearing cages, and ceramic ball bearings. Applications should be oriented to UAV engines with the intent to increase engine durability and reliability upon the implementation of these advanced durability concepts.

The objective of this USSOCOM Phase I SBIR effort is to conduct and document the results of a thorough feasibility study to investigate what is in the art of the possible within the given trade space that will satisfy a needed technology. The feasibility study should investigate all known options that meet or exceed the minimum performance parameters specified in this write up. It should also address the risks and potential payoffs of the innovative technology options that are investigated and recommend the option that best achieves the objective of this technology pursuit. The funds obligated on the resulting Phase I SBIR contracts are to be used for the sole purpose of conducting a thorough feasibility study using scientific experiments and laboratory studies as necessary. Operational prototypes will not be developed with USSOCOM SBIR funds during Phase I feasibility studies. Operational prototypes developed with other than SBIR funds that are provided at the end of Phase I feasibility studies will not be considered in deciding what firm(s) will be selected for Phase II.

PHASE II: Demonstrate promising innovative advanced durability systems determined to be feasible in Phase I and apply them to current UAV engines. The advanced durability systems will be demonstrated in a laboratory environment. Small scale testing of engines will be required to demonstrate increased durability using selected advanced durability systems.

PHASE III DUAL USE APPLICATIONS: This technology is applicable to Air Force, Navy, and Army UAS engines as well as additional application and commercial opportunities in the commercial sector.

REFERENCES:
1. SKF, 1994, “Bearing Failures and their Causes,” Product Information 401, pp.1-4.

2. Koyo, “Ball and Roller Bearings: Failures, Causes, and Countermeasures,” JTEKT Corp, Cat.No.B3001E, pp. 1-20.

3. Cundill, R.T., 1991, “High Precision Silicon Nitride Balls for Bearings,” SKF Engineering and Research Centre VB, The Netherlands.

4. Forster, N., Rosado, L., Brown, J., and Shih W., 2002, "The Development of Carbon-Carbon Composite Cages for Rolling Element Bearings," Vol. 45, No. 1, pp. 127-131.

5. Whalen, P.J., Gadsaka, C.J., and Silvers, R.D., 1990, “The Effect of Microstructure on the high-temperature Deformation of Behavior of Sintered Silicon Nitride,” Ceramic Eng. Sci. Proc., 11(7-8), 633-649.

KEYWORDS: Ceramics, Fuel Lubrication, Durability, UAV Engines

NOTE: During the Pre-Release stage of the 2016.3 DoD SBIR Solicitation, all technical questions related to this topic shall be addressed to sbir@socom.mil.

SOCOM163-003 TITLE: Advanced Tactical Facial Recognition at a Distance Technology

TECHNOLOGY AREA(S): Information Systems, Sensors

OBJECTIVE: To develop and demonstrate innovative advanced tactical facial recognition technologies at ranges of 650 meters to 1 kilometer to enhance tactical situation awareness and support positive identification of persons of interest. The tactical facial recognition technologies need to be capable of being reduced to man-portable size, weight, and power (SWAP) requirements. While this effort is focused on ground tactical applications, the expandability to airborne Intelligence, Surveillance, Target Acquisition, and Reconnaissance (ISTAR) applications is desired.

DESCRIPTION: The United States Special Operations Command (USSOCOM) requires the capability to identify hostile persons with a high degree of accuracy in a short period of time from communications disadvantaged locations. USSOCOM has a requirement for man-portable tactical facial recognition at a distance up to 1 kilometer. Emerging advanced facial recognition algorithms are demonstrating improved performance against non-ideal facial images, with further technology development ongoing for more robust performance with unconstrained facial images (examples include: occlusion, facial hair, bandana, hijab), face capture and extraction, and streaming video processing. Tactical facial recognition at long range present additional technical challenges requiring development and integration of multiple diverse technologies, including optical systems (for example: optical resolution, focus, aberrations), imaging sensors (for example: number of pixels, noise), atmospheric effects correction, super-resolution enhancement, motion/jitter stabilization/compensation, processing power, automated and user-friendly controls and display (for example: tablet, smartphone), and man-portability (SWAP, ruggedness).

PHASE I: The objective of this technology pursuit is to conduct a thorough technology feasibility study, including an analysis of the critical technical factors, constraints, and relationships affecting long-range facial recognition performance, with a top-level integrated system design. The study should identify/demonstrate the critical prototype technologies and scalability needed to achieve a man-portable SWAP form factor. The objective of this USSOCOM Phase I SBIR effort is to conduct and document the results of a thorough technology feasibility study to investigate what is in the art of the possible within the given trade space. The feasibility study should investigate all the known options that meet or exceed the minimum performance parameters specified in this write up. It should also address the risks and potential payoffs of the innovative technical options that are investigated and recommend the option that best achieves the objective of this technology pursuit. The funds obligated on the resulting Phase I SBIR contracts are to be used for the sole purpose of conducting a thorough feasibility study using scientific experiments and laboratory studies as necessary. Operational prototypes will not be developed with USSOCOM SBIR funds during Phase I feasibility studies. Operational prototypes developed with other than SBIR funds that are provide at the end of Phase I feasibility studies will not be considered in deciding what firms(s) will be selected for Phase II.

PHASE II: The Phase II effort shall develop a detailed design and conduct a scalable prototype demonstration of all critical technologies and attributes. The design development path to a ruggedized man-portable operational capability will be detailed.

PHASE III DUAL USE APPLICATIONS: Long range facial recognition technologies have dual-use applications beyond the Department of Defense, including law enforcement and security.

REFERENCES:
1. "National Institute of Standards and Technology Face Recognition Challenges and Evaluations": http://www.nist.gov/itl/iad/ig/facechallenges.cfm

KEYWORDS: Facial Recognition, Long Range Facial Recognition, Long Range Biometrics

NOTE: During the Pre-Release stage of the 2016.3 DoD SBIR Solicitation, all technical questions related to this topic shall be addressed to sbir@socom.mil.

SOCOM163-004 TITLE: Blood and Pharmaceutical Cooling and Storage System

TECHNOLOGY AREA(S): Biomedical

OBJECTIVE: Design an innovative portable device to safely cool (including freeze), transport and store blood, blood components, pharmaceuticals and related serums or solutions in remote and austere environments with limited reach back logistics support.

DESCRIPTION: Special Operations Forces' (SOF) medical teams require a multi-functional and transportable storage capability to safely keep blood, blood components, pharmaceuticals and related serums or solutions within controlled temperature ranges via external/internal power source(s). Blood and blood products must adhere to strict transport and storage requirements regulated by the Food and Drug Administration (FDA) in order to remain safe for use. Current problems associated with the transport and storage of blood and blood products has limited the availability of potentially life-saving interventions by front line medics and enroute care personnel. Current freezer/refrigeration systems used by the military are suitable for use in medical facilities only where sufficient power is available. However, these systems are not feasible for forward SOF operations due to size, weight, and power constraints. SOF medical teams require portable solutions to enhance their ability to move blood and blood products forward to austere environments.

PHASE I: Conduct a feasibility study to design a Blood and Pharmaceutical Cooling and Storage System that meets or exceeds the following parameters:

• The not to exceed exterior dimensions of the case are: 32" H x 20" W x 13" L (T). Smaller form factors are encouraged (O).

• Weight: 70 pounds (T), less than 70 pounds (O).

• Includes two separate Freezer /Cooler Drawers: The freezer/cooler must include two separate drawers systems, must be capable of storing a total of 24-28 liters. Separate temperature control with an exterior 24 hour historical measurement capability for each drawer system, to include open/closed transport period validation procedure. Each drawer must include adjustable dividers. Each drawer must be able to be secured/locked. The length and depth of the drawers should realize a maximum storage capacity given the dimensions of the exterior case and the equipment / insulation needed to meet the required cooling / freezing temperature requirements.

• Primary Power: 110/220, 12 Volt (Threshold (T)); 24 Volt capable (Objective (O)). The Primary Power system must be capable of charging the primary back-up power source when connected to an AC source.

• Primary Backup Power: The Primary Backup Power must be included in the case and must automatically and instantaneously provide uninterrupted power supply should the primary AC power source suddenly became unavailable. This Primary Backup Power supply must operate continuously for 6 hours (T), 8+ hours (O). The power charging requirements for the Primary Backup Power supply must be the same as for the Primary Power requirements: (110/220, 12 Volt (T); 24 Volt capable (O)).

• Secondary Backup Power: Provide an additional separate battery pack with charger that can be rapidly swapped with the Primary Backup Power supply (T=O). The power requirements for the Secondary Backup Power charging system must be the same as for the primary power requirements: (that is: 110/220, 12 Volt (T); 24 Volt capable (O)).

• Temperature Control, Freezer / Cooler Drawers: Both freezer / cooler drawers must maintain an internal compartment temperature range of -5 degrees (Minus 5) to 10 degrees Celsius (C) (T); -18 degrees (Minus 18) to 10 degrees C (O).

• Insulate internal drawer temperatures for up to 6 hours after complete power loss (T); 12 hours after complete power loss (O).

• Temperature Monitoring and Alerting: Must have an audible alarm and a continuous temperature recording system (T=O). Users must have a means of verifying temperature control throughout the storage and transport timeframe to ensure the integrity of the stored products. This timeframe can be variable such as a weekly or monthly monitoring capture and recording system. Proposed solutions should address a means to provide this verification with temperature displays. Proposed solutions must also provide an alerting system to notify users of aberrations in desired storage temperatures. Proposed solutions should continue to record even when main AC power is lost.

• Temperature Monitoring and Alerting: Wi-Fi availability to configured cell/notebook/laptops is desirable

(O).

• Temperature Monitoring and Alerting Power: Must have stand-alone battery power to actuate alarms and continue to record temperatures for 8 hours (T) to 24 hours (O) should primary and back-up sources of power fail.

• System must be capable of rapid set up and operations within 30 minutes (T); 5 minutes (O) without specialized tools or prior training.

• System must be capable of being stacked on each other 3 high horizontally (T) or 4 high (O) horizontally for storage and transport.

• System must have retractable handle and wheel system for easy transport (Examples of acceptable handle and wheel systems include the Pelican Hardigg MC4100, MC8100).

• System must be one man portable.

• System must operate in both the vertical and horizontal positions.

• Battery and cooling system must pose no harmful threat to humans or machinery during normal ground and flight operations.

• Battery and cooling system must pose no hazardous, caustic or combustible threat or cause undo risks if casings are ruptured or damaged.

The objective of this USSOCOM Phase I SBIR effort is to conduct and document the results of a thorough feasibility study to investigate what is in the art of the possible within the given trade space that will satisfy a needed technology. The feasibility study should investigate all known options that meet or exceed the minimum performance parameters specified in this write up. It should also address the risks and potential payoffs of the innovative technology options that are investigated and recommend the option that best achieves the objective of this technology pursuit. The funds obligated on the resulting Phase I SBIR contracts are to be used for the sole purpose of conducting a thorough feasibility study using scientific experiments and laboratory studies as necessary. Operational prototypes will not be developed with USSOCOM SBIR funds during Phase I feasibility studies. Operational prototypes developed with other than SBIR funds that are provided at the end of Phase I feasibility studies will not be considered in deciding what firm(s) will be selected for Phase II.

PHASE II: Develop and demonstrate a prototype that meet the performance parameters determined to be feasible during Phase I.

PHASE III DUAL USE APPLICATIONS: Portable Blood and Pharmaceutical Cooling and Storage System applications include a wide range of DoD mission sets, humanitarian and disaster response operations both CONUS and abroad by both the military and domestic and international nongovernmental response agencies. The system would also prove invaluable as a secondary or tertiary backup capability for more conventional systems when power sources are not consistent or may be regularly interrupted.

REFERENCES:
1. AFI 44-118 entitled “Operational Procedures for the Armed Services Blood Program” dated 1 September 2007 that can be accessed on the internet.

KEYWORDS: Blood products, blood storage, pharmaceutical storage, cold storage chain

NOTE: During the Pre-Release stage of the 2016.3 DoD SBIR Solicitation, all technical questions related to this topic shall be addressed to sbir@socom.mil.

SOCOM163-005 TITLE: Cloud Data Synchronization with Limited Bandwidth Communications

TECHNOLOGY AREA(S): Human Systems, Information Systems, Sensors

OBJECTIVE: Develop a system to preposition and synchronize data between capabilities deployed in austere environments and commercial or private cloud infrastructures.

DESCRIPTION: Data storage, processing and analysis capabilities are increasingly migrating to enterprise hosted cloud infrastructures however the requirement for the DoD to operate in austere environments remains. Further, the footprint of forward deployed analysts and support personnel continues to shrink, increasing dependence on CONUS based exploitation capabilities. As this occurs, timely access to data (both originating in the field and disseminated from CONUS becomes critical for effectively capitalizing on opportunities and mitigating threats in highly dynamic environments.

Efforts must be made to intelligently preposition, cache, and synchronize data in order to maintain operations when networks are highly constrained or completely disconnected in austere environments. Solutions should consider data that is collected from the field to be processed and utilized in analytic systems as well as information that is disseminated from these analytic systems which must be made available to users. In order to address conditions where networks are intermittent or nonexistent, intelligent caching of data and opportunistic and prioritized means for synchronization should be considered. Because many of these analytic systems are already in place or are in the processes of being operationalized the degree to which these data management mechanisms can be employed into existing software architectures will greatly impact the likelihood of their adoption. Additionally, the degree to which the data management process can be automated or initiated by the end user as part of their existing workflow will increase the likelihood of user acceptance.

PHASE I: Perform a feasibility analysis for bi-directional synchronization between applications deployed in a cloud infrastructure and capabilities (consumers or producers) in disconnected, intermittent, and limited (DIL) availability communications environments. Identify current approaches to DIL operations and their limitations. Identify technology that can be applied to the problem and evaluate the expected operational utility of potential solutions. The feasibility analysis should include components that transmit data to the cloud for processing (for example: sensors) as well as end user applications that consume data from cloud systems to present information to users in the field (for example: web or mobile apps). Important features to include in the feasibility analysis should include the utilization of open source or commercial components and anticipated total cost of ownership across the lifecycle.

The objective of this USSOCOM Phase I SBIR effort is to conduct and document the results of a thorough feasibility study to investigate what is in the art of the possible within the given trade space that will satisfy a needed technology. The feasibility study should investigate all known options that meet or exceed the minimum performance parameters specified in this write up. It should also address the risks and potential payoffs of the innovative technology options that are investigated and recommend the option that best achieves the objective of this technology pursuit. The funds obligated on the resulting Phase I SBIR contracts are to be used for the sole purpose of conducting a thorough feasibility study using scientific experiments and laboratory studies as necessary. Operational prototypes will not be developed with USSOCOM SBIR funds during Phase I feasibility studies. Operational prototypes developed with other than SBIR funds that are provided at the end of Phase I feasibility studies will not be considered in deciding what firm(s) will be selected for Phase II.

PHASE II: Provide a prototype implementation with representative system and data. Characterize performance under various network conditions and operationally relevant scenarios. Assess utility of user-centric tasks and workflows. Provide a proof of concept for the prioritization of data synchronization according to factors which may include but are not limited to the end user or application requesting synchronization, the type of data being synchronized, the mission it supports, and geographic region.

PHASE III DUAL USE APPLICATIONS: Mature the prototype developed under Phase II for operational use. The offeror can mature the design by adding features to meet other government (federal, state, and local) and commercial applications where data centric systems will be utilized in bandwidth limited or disconnected environments. To the greatest extent possible, demonstrate cloud and client architecture agnostic implementation for data distribution and synchronization with a focus on portable or mobile devices.

REFERENCES:
1. “Microservices”. (not dated). Retrieved June 29, 2016, from https://en.wikipedia.org/wiki/Microservices

2. “Department of Defense Cloud Computing Strategy,” July 2012. http://dodcio.defense.gov/Portals/0/Documents/Cloud/DoD%20Cloud%20Computing%20Strategy%20Final%20with%20Memo%20-%20July%205%202012.pdf

3. “On the Suitability of Mobile Cloud Computing at the Tactical Edge”, Defense Research and Development Canada (DRDC), 23 April 2014, DRCD Publication No. DRDC-RDDC-2014-L56. http://publications.gc.ca/collections/collection_2015/rddc-drdc/D68-1-56-2014-eng.pdf

4. “Tactical Cloudlets: Moving Cloud Computing to the Edge,” Lewis, G., Echeverría, S., Simanta, S., Bradshaw, B., & Root, J., (2014). http://elijah.cs.cmu.edu/DOCS/lewis-milcom2014.pdf

KEYWORDS: Commercial Cloud Services, Data Analytics, Software, Network Transport, Data Synchronization, Cloud Storage

NOTE: During the Pre-Release stage of the 2016.3 DoD SBIR Solicitation, all technical questions related to this topic shall be addressed to sbir@socom.mil.

SOCOM163-006 TITLE: Color Night Vision Sensor

TECHNOLOGY AREA(S): Air Platform, Electronics, Ground/Sea Vehicles, Sensors

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 5.4.c.(8) of the solicitation.

OBJECTIVE: The objective of this technology pursuit is to develop high resolution true color night vision sensors.

DESCRIPTION: The Department of Defense needs true color, high resolution night vision devices for both ground and air based operations. A single sensor that can be used in both day and night is required. Optimally, the sensor would not “bloom” from a bright source in the scene. The waveband of interest is the visible spectrum from approximately 400 – 750 nanometers. The presentation of light should be either true red, green, and blue or alternatively true cyan, magenta, yellow. (The red car must look red, the green tree must look green, and the blue water must look blue). The imagery should be 30 to 60 Hz with latency less than 1 second for fix wing intelligence, surveillance and reconnaissance applications. The objective sensitivity is down to clear sky no moon conditions, or 0.001 lux. The threshold sensitivity is clear sky quarter moon, or 0.01 lux. The illumination conditions for both these illuminations is 8 bits of color, or 256 color pallet. The objective is 16 bits of color. The threshold solution is HD720, or HD1280x720. The objective resolution is HD1080, or HD1920x1080. The threshold dynamic range should work from 0.01 lux (quarter moon) to 10^5 lux (sunny day) and at objective 0.001 lux (clear starlight) to 10^5 lux (sunny day). This technology pursuit focuses on a solution for fixed wing operationally relevant ranges.

PHASE I: Conduct a feasibility study to develop color night vision sensors that meet or exceed the performance parameters specified in the above paragraph titled “Description.” The feasibility study should also focus on developing innovative color night vision sensor technologies that:
- Determine the range at which a positive Identification of a person can occur.
- Determine if a person is armed or not as a function of range.
- Operate in both daylight and at night.

- Provide true color imaging.
- Fit within existing EO/IR gimbals (15”, 20” and 25” gimbals) and in smaller sized gimbals that the offeror determines is feasible.
- Use a sensor of at least Technology Readiness Level (TRL) 7 to include in performance calculations. TRL 7 is defined as: “System prototyping demonstration in an operational environment (ground or space): System prototyping demonstration in an operational environment. System is at or near scale of the operational system, with most functions available for demonstration and test. Well integrated with collateral and ancillary systems. Limited documentation available.”
- Link budgets considering the entire optical train, sensor sensitivity, and radiometric calculations.
- Estimate at Video National Imagery Interpretability Rating Scale (NIIRS) value estimated as a function of range.
- Simulate imagery as a function of range considering the link budgets, optical train, typical targets, Video NIIRS value, and sensor sensitivity.

The overall objective of a USSOCOM Phase I SBIR effort is to conduct and document the results of a thorough feasibility study to investigate what is in the art of the possible within the given trade space that will satisfy a technology need. The feasibility study should investigate all known options that meet or exceed the minimum performance parameters specified in this write up. It should also address the risks and potential payoffs of the innovative technology options that are investigated and recommend the option that best achieves the objective of this technology pursuit. The funds obligated on the resulting Phase I SBIR contracts are to be used for the sole purpose of conducting a thorough feasibility study using scientific experiments and laboratory studies as necessary. Operational prototypes will not be developed with USSOCOM SBIR funds during Phase I feasibility studies. Operational prototypes developed with other than SBIR funds that are provided at the end of Phase I feasibility studies will not be considered in deciding what firm(s) will be selected for Phase II.

PHASE II: Develop, test and demonstrate the color night vision sensor prototype that was determined to be the best solution for SOF aviation applications during Phase I. The sensor will be tested using a 20” gimbal. Ground test comparisons (using existing and low light cameras), a discussion of the reliability of the sensor, and the sensors scalability to be included in smaller and larger gimbals will also be included in Phase II.

PHASE III DUAL USE APPLICATIONS: Color night vision sensors have numerous applications for ground, air and maritime applications. They are also applicable for law enforcement applications.

REFERENCES:
1. “Motion Imagery Standards Board Recommended Practice – Video – NIIRS,” MISP RP 0901, dated 15 October 2009: http://www.gwg.nga.mil/misb/docs/rp/RP0901.pdf.

KEYWORDS: Color Night Vision, Aviation

NOTE: During the Pre-Release stage of the 2016.3 DoD SBIR Solicitation, all technical questions related to this topic shall be addressed to sbir@socom.mil.

SOCOM163-007 TITLE: Freeze Dried Plasma for Canines

TECHNOLOGY AREA(S): Biomedical

OBJECTIVE: Develop a stable, lyophilized plasma formulation for rapid use in canine trauma resuscitation that demonstrates safety and efficacy.

DESCRIPTION: Military Working Dogs have proven to be a vital component of significant warfighter missions, supporting warfighter security and mission implementation. A lack of appropriate canine transfusion products risks the lives of these dogs, as well as the success of the mission, when a dog suffers severe trauma in the field. Plasma is increasingly recognized as a life-saving product for severe trauma offering advantages over transfusion of blood alone. However, the use of plasma in battlefield situations is limited by logistical constraints. Maintaining stability of the plasma components often requires refrigeration or freezing, and the sheer bulk of the product hinders transport and distribution. However, lyophilized plasma provides a transfusion product with reduced volume, elimination of the need for cold storage, and the potential to concentrate anti-inflammatory molecules which may provide an added advantage. To date, experimental studies have demonstrated benefits of lyophilized plasma in a swine model, but with no other animal species.

The goal of this topic is to develop a stable, lyophilized plasma formulation that, when reconstituted, demonstrates safety and efficacy in canine trauma resuscitation. Plasma should be derived from healthy donor dogs that are negative for canine red blood cell antigens DEA 1.1 and DEA 1.2. Donor animals should also be tested for blood borne diseases including canine brucellosis, hemobartonellosis, Borrelia burgdorferi (Lyme disease), Dirofilaria immitis (heartworm disease), Ehrlichia canis, Rocky Mountain spotted fever, Coccidioides immitis, Babesia canis, Babesia gibsoni, Mycoplasma haemocanis and plasma levels of von Willebrand factor. All donor animals should be current on immunizations for canine distemper, hepatitis, parainfluenza, leptospirosis, parvovirus, Bordatella, coronavirus and rabies virus.

PHASE I: Develop methodology to collect and lyophilize canine plasma from healthy donor dogs meeting the blood type requirements cited above. Develop a reconstitution protocol that does not alter coagulation factor activity, pH or albumin levels compared to fresh plasma. The reconstitution protocol must be conducted with sterile water in less than 2 minutes. Demonstrate that following reconstitution, the product is negative for endotoxin and other hazardous components. Present a complete description of the lyophilized plasma product that clearly describes all components and/or additives and their relative abundance. Demonstrate safety and efficacy of the reconstituted lyophilized plasma product in vitro, as well as in experimental animal infusions. Evaluations should include, but are not limited to: coagulation factor levels, hematology, inflammatory profiles, and vital signs.

The objective of this USSOCOM Phase I SBIR effort is to conduct and document the results of a thorough feasibility study to investigate what is in the art of the possible within the given trade space that will satisfy a needed technology. The feasibility study should investigate all known options that meet or exceed the minimum performance parameters specified in this write up. It should also address the risks and potential payoffs of the innovative technology options that are investigated and recommend the option that best achieves the objective of this technology pursuit. The funds obligated on the resulting Phase I SBIR contracts are to be used for the sole purpose of conducting a thorough feasibility study using scientific experiments and laboratory studies as necessary. Operational prototypes will not be developed with USSOCOM SBIR funds during Phase I feasibility studies. Operational prototypes developed with other than SBIR funds that are provided at the end of Phase I feasibility studies will not be considered in deciding what firm(s) will be selected for Phase II.

PHASE II: Optimize the methodology to generate lyophilized canine plasma and the reconstitution protocol. Methods should be amenable to large scale production and economically sound. Evaluate the safety and efficacy of the lyophilized canine plasma product in a controlled canine clinical trial. All transfusion complications and adverse reactions should be noted. Evaluate the stability of the lyophilized plasma product and establish an expiration date. A shelf-life of greater than 2 years stored at 15°F-140°F is required. Develop final product specification documents that include a list of all product components and their concentrations, instructions for storage of the lyophilized plasma, instructions for reconstitution, instructions for administration, and a list of all chemicals and medications that may cross-react with the reconstituted plasma product.

PHASE III DUAL USE APPLICATIONS: The development of a lyophilized canine plasma product that meets the requirements outlined above will support the effective treatment of canine trauma in military and law enforcement settings, as well as civilian veterinary care capabilities, particularly in remote and rural areas. Canine and human physiology are similar, therefore products that can demonstrate proof-of-principle in the dog will have significant predictive value for new and innovative treatments for human trauma victims. The proposer should identify appropriate collaborative or transition partners who will be able to make this technology commercially available for the Military Working Dog.

REFERENCES:
1. Steil L, Thiele T, Hammer E, Bux J, Kalus M, Völker U, Greinacher A. Proteomic characterization of freeze-dried human plasma: Providing treatment of bleeding disorders without the need for a cold chain. Transfusion

(2008); 48(11):2356-2363.

2. Spoerke N, Zink K, Cho SD, Differding J, Muller P, Karahan A, Sondeen J, Holcomb JB, Schreiber M. Lyophilized plasma for resuscitation in a swine model of severe injury. Archives of Surgery (2009); 144(9):829-834.

3. Van PY, Hamilton GJ, Kremenevskiy IV, Sambasivan C, Spoerke NJ, Differding JA, Watters JM, Schreiber MA. Lyophilized plasma reconstituted with ascorbic acid suppresses inflammation and oxidative DNA damage. Journal of Trauma (2011); 71(1):20-25.

KEYWORDS: Plasma, Canine, Lyophilized, Reconstituted, Trauma, Transfusion

NOTE: During the Pre-Release stage of the 2016.3 DoD SBIR Solicitation, all technical questions related to this topic shall be addressed to sbir@socom.mil.

SOCOM163-008 TITLE: Tactical Sensor Data Processing, Exploitation, and Dissemination

TECHNOLOGY AREA(S): Air Platform, Battlespace, Electronics, Information Systems, Sensors

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 5.4.c.(8) of the solicitation.

OBJECTIVE: Special Operations Forces (SOF) require access to SOF-specific detailed tactical planning data to support military operations. To meet this requirement, highly accurate 3D Building Information Modeling (BIM), Computer Aided Design (CAD), and Geographic Information System (GIS) data is generated through garrison production as well as mobile collection in preparation for or during ongoing crises and contingency operations.

DESCRIPTION: SOF users need an innovative data repository that allows processing, exploitation and dissemination of what is in the tactical cloud. SOF unique needs also include: integrating the interior and exterior (environmental) data, a modular open system architecture, and a standards based repository for open industry format 3D data collected via multiple sensors and sources. SOF seeks innovative game-changing technologies that allow interoperability of data used for battle space awareness across SOF Command and Control (C2), planning, rehearsal, analysis and operations. The imagery and spatial data is used to create urban and wide-area high resolution 3D surveys with level of accuracy to the sub-centimeter. Data must interoperate with other CAD and GIS data in open industry formats. Innovative technologies should automate data upload, produce and export geo-referenced maps, elevation models, and point clouds in industry standard, high resolution formats as well as smaller, user friendly formats like 'GeoPackage' for integration with existing GIS workflows. The technologies should operate in a commercial, DoD, or hybrid cloud based Federal Risk and Authorization Management Program (FedRAMP) compliant network. The innovative technologies must meet Defense Information Systems Agency Security Technical Implementation Guides (STIG) mandatory requirements. The data must meet to security information Impact Level 4 (Controlled Unclassified Information, For Official Use Only). Tasks that the data repository must enable through open industry standard formats include:

- Rapid visualization of topographic-bathymetric data including primary spatial dimensions with 15-30 centimeters accuracy integrated with other data using commercial and open source tools.
- Rapid visualization of BIM data including lighting analysis, building properties (materials), and primary spatial dimension with sub-centimeter accuracy.
- Conversion of point cloud data to polygonal structured data.
- Integration of multiple point clouds into single 3D models and scene visualizations.

PHASE I: The overall objective of a USSOCOM Phase I SBIR effort is to conduct and document the results of a thorough feasibility study to investigate what is in the art of the possible within the given trade space that will satisfy a technology need. The feasibility study should investigate all known options that meet or exceed the minimum performance parameters specified in the above paragraph titled “Description”. It should also address the risks and potential payoffs of the innovative technology options that are investigated and recommend the option that best achieves the objective of this technology pursuit. The funds obligated on the resulting Phase I SBIR contracts are to be used for the sole purpose of conducting a thorough feasibility study using scientific experiments and laboratory studies as necessary. Operational prototypes will not be developed with USSOCOM SBIR funds during Phase I feasibility studies. Operational prototypes developed with other than SBIR funds that are provided at the end of Phase I feasibility studies will not be considered in deciding what firm(s) will be selected for Phase II.

PHASE II: Develop a software technical data package and executable / installable software that demonstrates that the innovative technology meets the requirements specified in this topic write-up. The software will be assessed in a comparable environment with actual data that SOF uses to ensure the technology is suitable for its intended use.

PHASE III DUAL USE APPLICATIONS: Agriculture: for crop assessments and characterization. Construction: for monitoring of project progress, the location of equipment, and the volume of materials left. Mining: for calculation of aggregate volumes, to keep track of equipment locations and monitoring of safety environmental compliance.

REFERENCES:
1. “DoD Technology Readiness Levels”: http://www.nasa.gov/pdf/458490main_TRL_Definitions.pdf

2. “Information Assurance Support Environment”: http://iase.disa.mil/Pages/index.aspx

3. “FedRAMP”: https://www.fedramp.gov/

4. “GeoPackage”: http://www.geopackage.org/

KEYWORDS: Tactical Sensors; Intelligence, Surveillance, and Reconnaissance; ISR; Processing Exploitation and Dissemination; PED; 3D; Building Information Modeling; BIM; Computer Aided Design; CAD; Geographic Information System; GIS; Surveys; Maps; Open Standards

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SOCOM163-009 TITLE: Transparent Emissive Microdisplay

TECHNOLOGY AREA(S): Electronics, Human Systems

OBJECTIVE: Design and fabricate a full-color transparent emissive microdisplay for use in a multi-imaging plane system.

DESCRIPTION: The DoD has a need for breakthrough transparent emissive microdisplays for use in Augmented Reality systems. Transparency provides a platform to comingle multiple imaging sources with a single projection lens system without the need for combining prisms.

In order to bridge the gap between traditional night vision goggles (NVGs) and a fully digital night vision system with embedded augmented reality, an interim hybrid system is required. Traditionally, a hybrid system implements a beamcombiner prism and display to optically combine the two images and present it to the user. This methodology dramatically increases the size and weight of a typical night vision goggle.

This topic seeks to implement state of the art display drive electronics with a transparent display technology (e.g. TFEL, carbon nanotube emission, OLED, etc.). The preferred implementation utilizes a thin transparent and emissive display with 20µm or smaller pixel pitch, placed on the image intensifier output to optically combine the information without a beamcombiner. The emphasis of development is on full-color emissivity, with a minimum of interstitial pixel structure to minimize obscuration.

While basic in technology, the application requires careful consideration of the layered image structures. The image intensifier fiber optic output structure is a square 5 or 6 µm pixel pitch. A display layered on top requires a structure of equal spacing aligned to the intensifier output to minimize interference patterns (moire effects).

Proposals should target the design and implementation of a full-color, transparent, emissive display technology with pixel-pitch of 20µm (or smaller), and an area which exceeds the image intensifier's 18mm circular effective area. Refresh rates should be 30Hz or better, but power should not be sacrificed for refresh rate. Display drive circuitry should be implemented to receive a standard video or display drive format (e.g. HDMI, VGA, DisplayPort, Display Parallel, LVDS, or MIPI DSI) and show the incoming signal on the microdisplay. Test components can be demonstrated by using Schott or Incom fiber optics.

Critical to the design of the system is a path to field implementation. The requirements of a fielded system include:

- Mating to the 18mm fiber optic output of an image intensifier
- Emissive technology capable of variable brightness from zero (0) to greater than 6 footlamberts
- Overall transmission greater than 50%
- Small interstitial obscurance (less than 2µm)
- Approximately 18mm circular display
- Minimization of power consumption
- Minimization of rear-side substrate thickness (to minimize image plane separation)
- Electronics layout capable of being packaged within an image intensifier area footprint

Important design characteristics are those items which provide the user with a beneficial experience in an Augmented Reality implementation. Although important, these characteristics should be traded in deference to the critical characteristics. Those features include:

- Good color gamut
- Refresh rate of 30 Hz or faster
- Fast On/Off emission times (pixel response)
- Minimal pixel bleed-over or blurring at the image plane
- Good fill factor (>70%)
- Minimization of drive electronics
- Common video format (MIPI DSI preferred)

The proposer should carefully consider and document the technical challenges, both in display development and in systems implementation. Considerations such as video protocol, potential performance trades, image quality, and transition to production. Offerors are to first uncover and understand the critical integration challenges that may limit the translation and commercial-viability of display transparency as well as the potential pitfalls in overlaying two emissive display sources at slightly different image depths.

Technical challenges may include:

- The development of interface electronics to drive the emissive display.
- Reformatting existing display technologies to achieve the necessary transparency and form factor to achieve the stated goal.
- Eliminating visible flicker or refresh patterning.
- Establishing optimal trade-offs between physical, electronic, and optical performance specifications required to minimize the effect of the display on the overall night vision goggle system.
- Sourcing state-of-the-art display and electronics packaging support.

PHASE I: Explore and determine the fundamental technology, systems integration, and packaging limitations in implementing a full-color, transparent, emissive microdisplay. Provide a Final Report that identifies the technology utilized; details the technical challenges relevant to the implementation within the deployment environment; quantifies the limitations to the system relative to the information input/output of the display; details achievable performance metrics; describes integration process, system-level challenges; and a thorough business plan describing the Non-Recurring Costs, minimum rate of production, units per year required to achieve sustainable production of a transparent emissive microdisplay, and market analysis.

PHASE II: Develop a fully operational proof-of-concept demonstration of the key components and functional systems in a bench-top / PC-board scaled prototype along with all the design documents and complete specifications along with documentation of committed sources and service providers for the fabrication of the device to be produced in Phase II. Demonstrations should be performed with relevant components (i.e. fiber optic output) analogous to the final deployment environment in an image intensifier-based night vision goggle. Additionally; develop, demonstrate, and delivery a working fully-integrated transparent, emissive microdisplay. The Phase II demonstration should operate within a night vision goggle prototype that mimics as closely as possible the electrical and mechanical properties of a functional system. The integrated system should leverage COTS silicon and electro-optical devices wherever possible, and form a dual-layered imaging system, providing Augmented Reality inputs overlaid on a typical Image Intensified NVG system. The external interface should be a commercial standard interface, or display custom interface that may be readily adapted to. If the latter, drive electronics must accompany the unit which perform the interface operation. Proposers are encouraged to adapt modular componentry strategies that is generalizable to a wide range of video interfaces. The Phase II final report shall include (1) full system design and specifications detailing the electronics and proof-of-concept displays to be integrated; (2) expected performance specifications of the proposed components; and (3) expected improvements achievable through continued refinement of the design.

PHASE III DUAL USE APPLICATIONS: Transparent displays are a smaller and lighter replacement technology for the traditional method of information injection into optical systems. The traditional method uses a beamcombiner prism and additional lens elements to combine two optical paths. A transparent display enables a single optical path, minimizing the volume required. This method is useful in commercial areas such as:

- Digitally enhanced weapon sights (to inject range information, shot counters, configurable reticles, and images into the sight's optical path).
- Binoculars (for display of azimuth, inclination, focus range, and even images). Specific desires exist for bird watching, to display images of the target bird in the binocular view while observing real subjects.
- Augmented Reality light-field displays for head-wearable see-through computing.

KEYWORDS: Transparent Emissive Microdisplays, Augmented Reality

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